GLAST Large Area Telescope

Calorimeter Subsystem

5.1 Dual PIN Photodiode

J. Eric Grove
Naval Research Lab, Washington DC
Calorimeter Instrument Scientist

eric.grove@nrl.navy.mil
(202)–767–3112

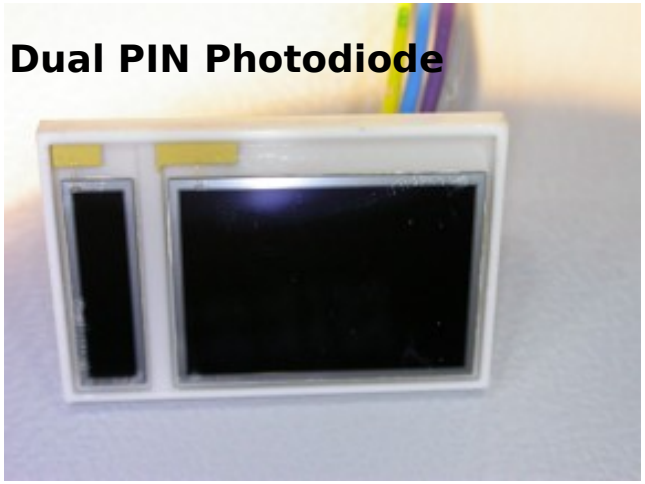
DPD Outline

- Goals and History
- Responsibilities and Status
- Requirements
- Changes from EM to FM
  - Highlight: Optical Window
- Qualification Program
- Procurement
- Schedule

Goals and History

- **Requirements on DPD are linked to the performance of the CDE and ultimately CAL**
  - **Collects the light from energy depositions in the CsI (SIGNAL)**
  - **DPD electrical characteristics (capacitance and dark current) affect the front end electronics NOISE**
  - **Desire is to maximize SIGNAL/NOISE**

CAL EM Dual PIN Photodiode



7 years of DPD development

NASA ATD Program

Commercial PIN

PIN Diode	Dates	Optical Window Material	Silicon Die thickness (um)	PIN A Area (mm^2)	PIN B Area (mm^2)
S3590	1/1996 – 12/1998	Hard epoxy resin		n/a	100
S3590-08 SPL	2/1999 – 10/2001	Hard epoxy resin	200	24	96
S8576	1/2001 -	Hard epoxy resin	300	25	152
S8576-01	2/2003 -	Silicone resin	300	25	147

EM DPD

Flight DPD

Responsibilities and Status

- **FM Requirements and Specs – joint responsibility of NRL and CEA**
  - **Worked closely with Hamamatsu in USA and Japan**
- **FM Procurement – joint responsibility of NRL and CEA.**
  - **CEA contributions**
    - **qualification and acceptance screening of all DPD**
    - **procurement of ~$200K (USD) in flight diodes**
  - **NRL contributions**
    - **overall management of the effort,**
    - **coordination and negotiation of the specification, and**
    - **procurement of the residual flight diodes (~$400K)**
- **FM Status**
  - **Specification is complete: LAT-DS-00209-12**
  - **Successful Procurement Readiness Review: 13 Feb 03**
  - **Qualification program will begin June 03**
    - **Evaluation of pre-production FM DPDs in progress now**

DPD Requirements

- **CAL Flight Dual PIN Photodiode Specification, LAT-DS-00209-12**
  - **Electrical and Optical Requirements**
    - **Area, sensitivity, dark current, capacitance, bias voltage**
  - **Ceramic Carrier Requirements – mechanical**
    - **Dimensions and tolerance control, electrical leads**
  - **Manufacturing Requirements**
    - **Die attach, wire bonds, optical window encapsulant**
  - **Product Assurance Requirements – Qualification and screening**
  - **Environmental Requirements**
  - **Deliverables – Documentation and data package**
  - **Shipping and handling**
  - **Acceptance Criteria**
- **Crystal Detector Element Specification, LAT-SS-01133-02**
  - **DPD bonding to CsI**
  - **Electrical lead treatment and positioning**

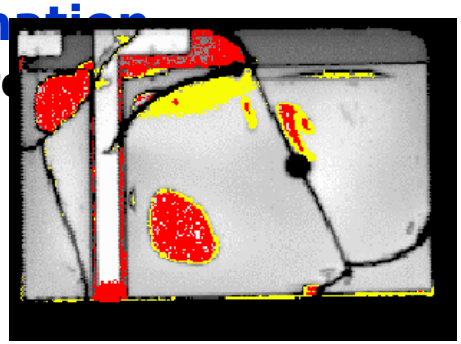
Changes from EM to Flight DPD

- **Several changes have been made based on EM lessons**
  - **Ceramic carrier size: S8576-01 carrier is 1 mm smaller in width and length**
  - **PIN B silicon die active area: S8576-01 die is 0.5 mm smaller in one dimension (~3%)**
  - **Electrical lead positions have been moved**
  - **Electrical leads shall be tinned by Hamamatsu prior to assembly of the silicon die to the carrier**
  - **Optical window encapsulant is changed to Shin Etsu KJR 9022E silicone resin**
  - **Shipping container has been modified to provide ESD protection and to protect the electrical leads from bending**

Let's talk about this one

Optical Window Issues

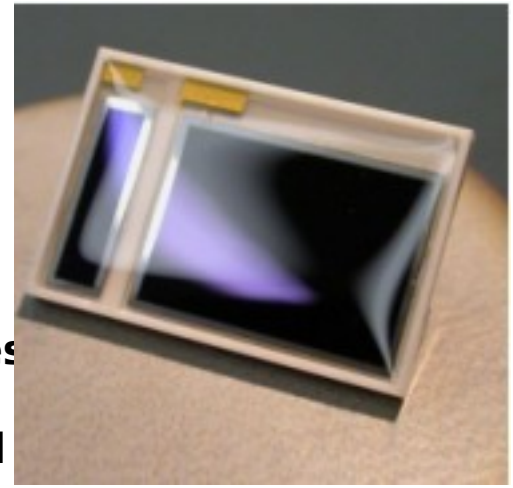
- **The problem with EM**
  - Hard epoxy window of EM S8576 could not withstand thermal cycling (-30C to +50C, 100 cycles)
    - Extensive testing program in France and US
      - ~650 units used in bonding, thermal, optical, etc. studies
    - "Microcracks", severe cracks, delamination
      - Latter two could cause electrical failure
  - But otherwise it worked well
    - Bonds to crystal were excellent and exceeded specs
      - Mechanical strong
      - Thermally stable
      - Optically clear



Acoustic microscopy of failed window

- **The solution for FM**
  - Make the window flexible: ShinEtsu silicone

Optical Window Verification



- **Verification program for ShinEtsu window**
  - **Report LAT-TD-1476-01**
  - **Tested performance of commercial PDs and sample EM DPDs with ShinEtsu window**
    - **Thermal stability of window**
      - **No cracks or delam at up to 180 cycles**
    - **Out-gassing**
      - **After bake-out, passes Mass Loss and Condensible Volatiles requirements**
    - **Bond compatibility**
      - **Forms fully-cured, strong bonds with optical adhesive for CsI(Tl)**
    - **Optical properties**
      - **Light yield: ~90% of hard epoxy**
      - **Thermal stability of optical bond: No significant loss of light after >100 cycles**
    - **Mechanical strength of bond**
      - **Tensile strength: >160 N (spec is >10 N)**
      - **Shear strength: >0.80 N/mm^2 (spec is >0.12 N/mm^2)**
  - **Conclusion: DPD with ShinEtsu silicone window still exceeds specs**

Qualification Program

- **Qualification program for FM DPDs is responsibility of CEA**
  - **Begins June 03**
  - **Discussed in agenda item 5.3**
  - **Principle tests**
    - **Solderability of leads**
    - **Moisture uptake**
      - **ShinEtsu window**
    - **Thermal cycling**
      - **stability of ShinEtsu window**
    - **Operating lifetime**
    - **Radiation hardness**
  - **Tests of pre-production samples are in progress now**
  - **Expect no issues**

Procurement Quantities

Level	Operation or Loss Process	Loss %	Loss Count	TOTAL CNT
CDE	**Required CDE for Flight**			**1728**
	Flight Spares	6.4%	110	1838
	CEA Delivery to NRL			**1838**
	Acceptance Test Failures	1.0%	19	1857
DPD	**DPD for CDE Acceptance Test**			**3714**
	Bonding Process Fallout	10.0%	413	4127
	PhotoDiode Assy Fallout	2.0%	84	4211
	Solder/Stake Failures	1.0%	43	4254
	Spare DPD	2.0%	87	4341
	Electrical Screening Fallout	1.0%	44	4385
	Dimensional Fallout	1.0%	44	4429
	Lot Acceptance Test	1.0%	45	4474
	DPD Qualification		60	4534
	DPD Evaluation		48	4582
	Bonding Process Development		100	4682
	TOTAL DPD Requirement			**4682**

Deliveries in quantities of 600 DPD

Schedule

- **First flight deliveries needed June 2003. Hamamatsu requires 3.5 months to manufacture.**
  - **First two months of manufacturing are for fabrication of the ceramic carriers. Assembly and test of the DPD are the remaining time.**
- **Deliveries are based on 600 diodes at 5 week intervals for the first four deliveries and 3 week intervals for the remaining four deliveries**